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Economic evaluation of MEG injection and regeneration process for oil FPSO

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ABSTRACT

Injection and regeneration of MEG for an offshore oil field to prevent the risk of hydrate formation was compared to those of conventional hydrate inhibitor, MEOH (methanol). It was presumed that the injected MEG was regenerated in FPSO to 90 wt% concentration while the MeOH was simply treated without re-use. A multiphase simulation tool was employed to determine the temperature and pressure profile in subsea flowline, which provided the required concentration of hydrate inhibitors for hydrate prevention. While the required concentration of MeOH was around 18 to 30 wt% depending on the water depth, the concentration of MEG was varied from 28 to 46 wt%. NPC (net present cost) for MeOH and MEG injection was estimated as a function of injection count per year with economic assessment. The resulting NPC of MEG injection system for single injection event per year was expensive than that of MeOH injection system due to the higher total capital costs for MEG injection and regeneration system. However, the economic benefit of MeOH systems was decreased with increasing the injection event frequency because the injected MeOH cannot be recovered, and increasing storage tank and purchased MeOH cost were directly added to the total cost. When varying the water depth, i.e. ambient sea water temperature of the offshore oil field, the minimum number of injections per year was different for the MEG injection system to be economically favorable than the MeOH injection system. It became economically favorable when injected more than 2.2 times per year for the case of water depth 1250 m, while it required more than 3.3 times per year for the case of water depth of 600 m. The results showed that the MEG injection and regeneration system can be a feasible option for remote oil fields depending on the average number of hydrate inhibitor injection per year.

1. Introduction

One of primary focus for the design and operation of subsea production system is the prevention of gas hydrate formation in subsea flowlines as its formation may cause blockage leading to costly production stoppage and complex remediation (Kim et al., 2014; Ning et al., 2010; Sloan and Koh, 2008; Sloan et al., 2009). Recently the energy industry moves into deeper and remote regions to exploit oil resources, where the subsea flowlines would be operated under low temperature and high pressure. Gas hydrates might be formed under this operation condition by crystallization of water molecules encapsulating light hydrocarbon molecules such as methane, ethane, and propane. Thermodynamic hydrate inhibitors (THIs) such as methanol (MeOH) and mono ethylene glycol (MEG) have been used to prevent hydrate formation in subsea flowlines by shifting the hydrate equilibrium curve toward lower temperature and higher pressure (Kan et al., 2002; Matthews et al., 2002).

The amount of hydrate inhibitor required to achieve complete inhibition may render the offshore field economically infeasible, demanding flow assurance engineers to consider the optimization of hydrate inhibition strategies. Although MeOH has been widely used as a hydrate inhibitor for oil production system, MEG also can be considered due to its lower vapor pressure and better safety. MeOH has low boiling point and high vapor pressure leading to high loss to hydrocarbon phase and is difficult to recover (Brustad et al., 2005; Bullin and Bullin, 2004). When MeOH is selected as a hydrate inhibitor, the operating expenditures could be increased with increasing volume of MeOH due to lost to gas and liquid hydrocarbon phases. In contrast, MEG has lower vapor pressure

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and loss to the hydrocarbon phase is negligible (Bruinsma et al., 2003; Brustad et al., 2005; Gupta, 2010). Due to its high boiling point, MEG can be recovered easily by MEG regeneration unit which is composed of a conventional distillation column to separate water from MEG and a flash separator to remove dissolved salt ions. Another advantage of using MEG in the offshore platform is the lower operational risk than MeOH as it is non-flammable. In general, MeOH is classified as a hazardous chemical due to its toxicity, high vapor pressure, low flash point and high flammability (Brustad et al., 2005; Steinbakk, 2012). Moreover the evaporated or dissolved MeOH into hydrocarbon phase could cause troubles in downstream oil and gas processing units, which may induce cost penalties for hydrocarbon sales depending on the dissolved MeOH concentration (Sloan, 2000). For example, if the MeOH concentration in condensate phase is higher than 50 ppm, the reduction in price is between 2 and 4 USD per metric ton. It may even be excluded from some hydrocarbon crackers if the MeOH concentration is higher than 100 ppm and most hydrocarbon cracker in refinery cannot be operated if the concentration of MeOH in condensate is larger than 200 ppm and must be handled first with pre-treatment unit to remove MeOH. However, MEG doesn't affect the specification of oil and gas products from the oil field (Son and Wallace, 2000a).

Therefore injection and regeneration of MEG in offshore oil fields might be feasible as the cost penalties can be avoided and the raw material costs will be reduced during the field life. However, there has been limited works investigating the use of MEG in oil production system as the thermodynamic hydrate inhibitor (Bikkina et al., 2012; Bruinsma et al., 2003; Brustad et al., 2005; Bullin and Bullin, 2004; Fadnes et al., 1998; Gupta, 2010; Kelland et al., 1995; Mokhatab et al., 2007; Obanijesu et al., 2014; Son and Wallace, 2000b). Most of previous studies focused on the physical properties and thermodynamic hydrate equilibrium conditions of MEG and MeOH although the cost analysis of the hydrate inhibition system would be essential to select the best inhibition strategy during the design of offshore production system. Mokhatab et al. (2007) and Brustad et al. (2005) studied the economic feasibility of regenerating MeOH and concluded that MeOH was not recommended to regenerate in most development cases. A large amount of loss would occur in the distillation column during regeneration, and an additional column is required to separate methanol remaining in the aqueous phase. Thus the methanol recovery is not economically favorable in most cases. Son and Wallace (2000b) studied the economics of using either MEG or MeOH for hydrate inhibition by calculating CAPEX and OPEX for gas condensate field located at Gulf of Mexico. The results suggested the annual chemical costs of MEG was more economic than MeOH even with regeneration facilities because MeOH was lost to gas phase and unable to be recovered. Demirbas (2010) concluded that the cost of MeOH highly affected the change of material cost and production rate than MEG because the required amount of MeOH was increased due to its loss in oil and gas phases on increasing production rate while MEG could be regenerated and barely lost to hydrocarbon phases. Brustad et al. (2005) reported the injection and regeneration of MEG for Norwegian offshore gas fields along with the review of CAPEX and OPEX by using MEG instead of MeOH. They suggested the MEG injection and regeneration process can replace the MeOH injection system in case of intermittent injection for offshore gas condensate field. Previous studies have been focusing on the gas dominant system and there are scarce works about the economic analysis for MeOH and MEG for the hydrate inhibition in oil dominant system.

In this study, we investigated the economic feasibility of the MEG injection with regeneration process for the offshore oil production system in comparison with the MeOH injection system. The multiphase flow simulation tool, OLGA, was used to calculate the amount of hydrate inhibitor to be injected into subsea production system during the restart operation after the extended shut-in. The simulation results was used to estimate the net present cost of hydrate inhibition system including operating cost (OPEX) and total capital investment (CAPEX) during the field life, where the number of inhibitor injection event per year was considered as a major influencing factor. Multiphase flow simulation results are coupled with the process simulation results using Aspen HYSYS to calculate the size and cost of MEG regeneration process.

2. Modeling and simulation

In this study, an offshore oil field with subsea production systems and a FPSO was considered for a case study to compare the economic feasibility of hydrate inhibition systems, i) MeOH injection, ii) MEG injection and regeneration process. Fig. 1 presents a schematic of overall process to

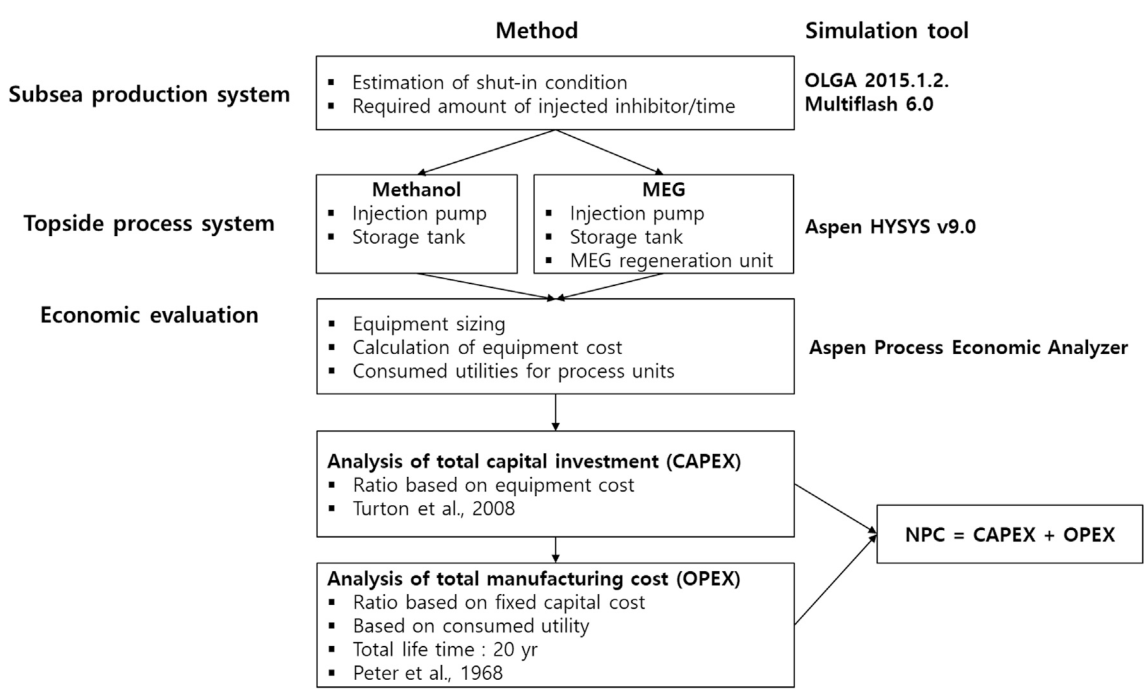

Fig. 1. Schematic of economic evaluation of this work.